22c:131 Limits of Computation

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SUMMARY

Guide to Course: 22C:131

Description: Topics covered include Turing machines, undecidability, complexity classes, reductions, NP-completeness, NP-complete problems, randomized algorithms and randomized complexity classes, approximation algorithms and related complexity classes, dealing with NP-completeness.

Goals and Objectives: 22C:131

This course is a mathematical exploration of the limits of the power of computers. Some of the questions we ask and attempt to answer are the following.

- Are there problems that cannot be solved on any computer?
- How does one determine if a given problem can or cannot be computationally solved?
- If we place bounds on the resources (time and space) available to a computer, then what can be said about which problems can and which problems cannot be solved on a computer?
- How does the power of a computer change, if it has access to random bits? What happens when we relax the notion of solving a problem to "approximately" solving a problem - does this fundamentally change which problems can and which problems cannot be solved on a computer?

Turing Machines (Ch. 3)

- Standard Turing machine: One read/write tape
- Multiple tape Turing machines
- Nonderministic Turing machines
- Enumerates
- Functions computed by Turing machines
- Description of Turing machines
  - each high-level description performs a finite number of moves
  - it is possible to decribe each individual moves in a high-level description.

Decidability and Reducibility (Ch. 4 & 5)

- Deciders vs. recognizers
- Examples of decidable languages
- First example of undecidable languages
- Mapping reducibility
- Computation histories

Time Complexty (Ch. 7)

- Big-O and small-o notations
- Complexity relationships among models
- Class P
- Class NP
- NP-Completeness

Space Complexity (Ch. 8)

- Savitch's Theorem: NSPACE$(f(n) \subseteq$ SPACE$(f(n)^2)$
- Class PSPACE
- PSPACE-Completeness

Advance Topics (Ch. 9 & 10)

- Space Hierarchy
- Time Hierarchy
- Approximation Algorithms (not in test)
- Probabilistic Algorithms (not in test)